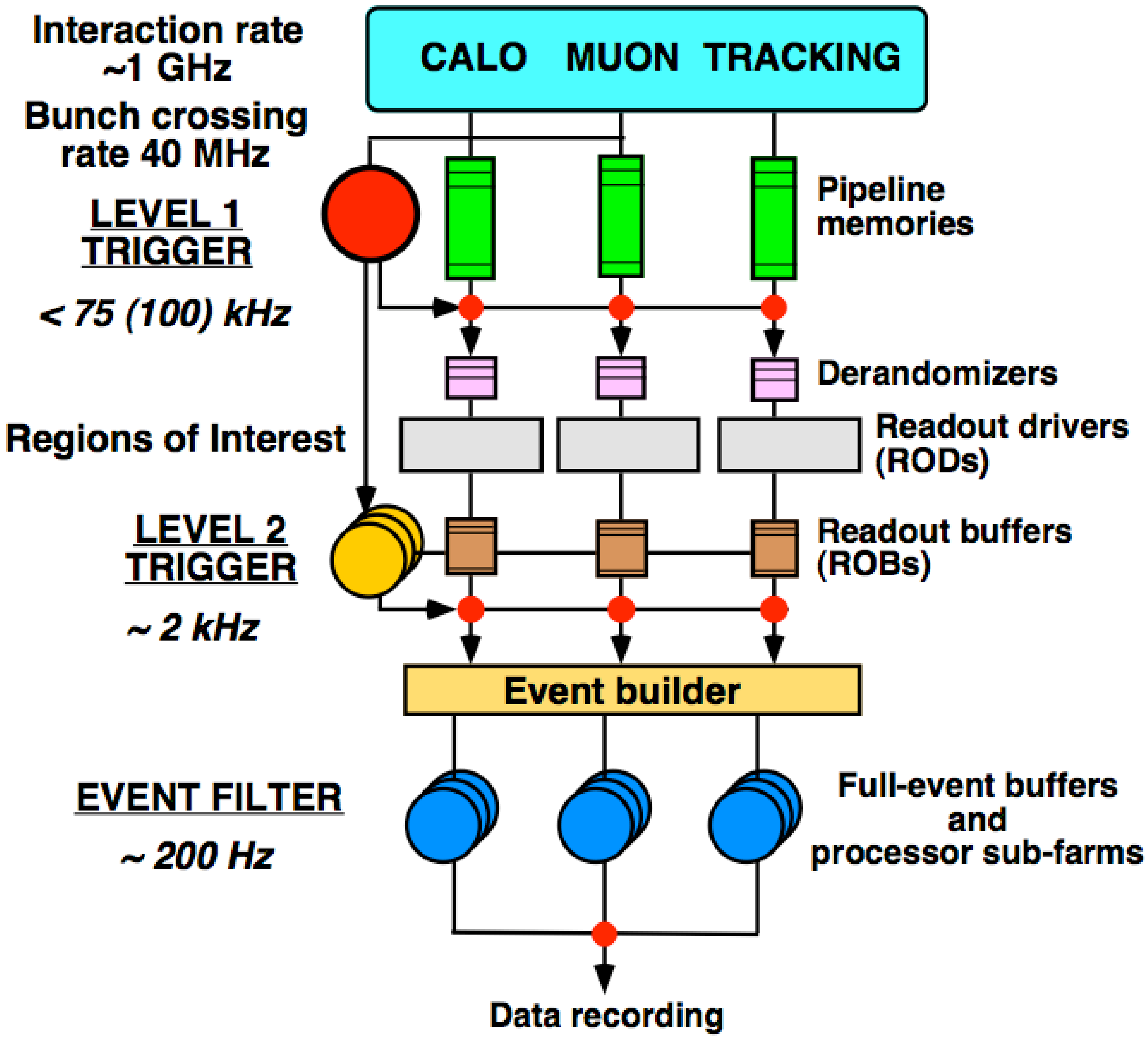
Measuring Trigger Efficiency

- Important component of cross section measurement: it is NOT in general 1.0!
- Need to measure this from data because trigger hardware is not emulated perfectly in software
- We will see this depends on the analysis in question (by my definition)

Three-level trigger schematic

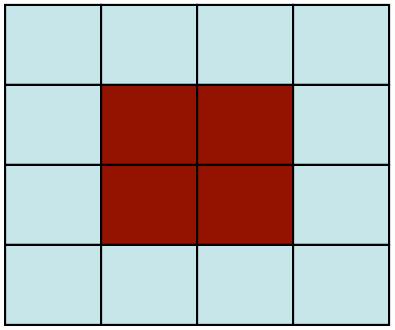


Trigger towers / Regions of Interest

- LVL1 uses trigger towers of size 0.1 x 0.1
  - Combines multiple EM cal towers
  - Passes a RoI to the LVL2 algorithms with similar resolution
- LVL2 uses fine segmentation 0.025 x 0.0245
  - Shower shape calculations
  - Tracking information
- See also ATL-DAQ-2000-002 “Selection of high-pT electromagnetic clusters by the level-2 trigger of ATLAS,” by Saul Gonzalez et al.

Specific LVL1 shower criteria

- Electron E_T in 1x2 trigger tower > 25 GeV
- Electromagnetic ring isolation (in 12 towers around 2x2 core) < 3 GeV
- Hadronic core leakage (in 2x2 towers behind EM cal) < 2 GeV
- Hadronic ring isolation (in 12 towers around 2x2 core) < 2 GeV



Specific LVL2 shower criteria

- Hadronic leakage: EM showers deposit little energy in the Had Cal. 2.5% or less
- Lateral shower shape 3x7 compared to 7x7: ratio >0.90
- Lateral width: variance of the 3x5 cell block
- Energy difference between two maxima in first ecal sample: this gets rid of jets with π^0 decays
  - energy in second maximum
- Total shower width relative to first energy maximum

Trigger Efficiency Definition

- Measured with respect to offline reconstruction. Why?
- $N = \sigma \times \varepsilon_{trig} \times \varepsilon_{reco} \times L$
- So L1 eff = N(pass L1) / N(reco)
- L2 eff = N(pass L1 && pass L2) / N(reco)
- There is at least one alternative to this definition…

Ensuring Real Electrons

- Electrons in inclusive stream come from W/Z production but also include fakes!
- Trigger efficiency measurement requires a reliable source of clean electrons. Why?
  - *Note that any "electron" would do as long as its shower shape and isolation characteristics are same as for true electrons -- this is unlikely*
- Tight electron requirements and Z mass selection ensure we are dealing with true electrons

Trigger Hypothesis

- Trigger algorithm which checks for a certain signature: e, γ, jet
- TrigT1EMHypo, TrigL2CaloHypo, TrigL2IDCaloHypo, TrigEFEgammaHypo
  - L1 (calo-based): calo energy, isolation
  - L2 (calo): shower shape, energy isolation in cone
  - L2 (track): match to L2 ID track
  - EF: nearly the same as offline requirements

Global Trigger Decision

- After rerunning the trigger hypotheses, trigger decision is in StoreGate under key “MyTriggerDecision” (or “MyTriggerDecision+”)

```
// find summary trigger decision
const TriggerDecision* trigDec = 0;
StatusCode sc=m_storeGate->retrieve( trigDec,
                                    "MyTriggerDecision");
if( sc.isFailure()  ||  !trigDec ) {
      mLog << MSG::WARNING
           << "No TriggerDecision found in TDS"
           << endreq;
      return StatusCode::FAILURE;
}
```

Parsing the Trigger Decision

- Trigger decision is packed into a word which needs to be parsed
  - Check that your trigger is defined in the current table
  - Then check that the event passes the trigger
  - Otherwise snap out of the event

```
// check trigger status before continuing
if (! (trigDec->isDefined("L2_e25i", 2)
    && trigDec->isTriggered("L2_e25i")) )
    return StatusCode::SUCCESS;
```

Will be interesting to compare this with the EventHeader bits

Trigger Objects

- L1EMTauObject
  - HdCore, EmCore, HdIsol, EmIsol
- TriggerElectron (L2)
  - Links to associated cluster and track

Retrieving Trigger Objects

```
for (l1EmObjectItr = l1EmContainer->begin();
      l1EmObjectItr < l1EmObjectItrE;
      l1EmObjectItr++) {
        mLog << MSG::DEBUG
             << "EmCore / Eta values for this L1 EM trigger object are "
             << (*l1EmObjectItr)->L1EM_EmCore() << " / "
             << (*l1EmObjectItr)->L1EM_eta() << endreq;
}
```

“Tag and Probe” Method

- Trigger on one electron (“tag”) and measure efficiency to trigger on the second electron (“probe”). Why not use just one electron?
  - Biased trigger efficiency (you need at least one trigger electron!)

- Alternative is to use backup (calibration) trigger paths which pass events through without biasing selection

Trigger Efficiency Derivation

Based on counting number of events, not electrons!
Specify number of single-trigger object (M. Flowerdew)

Case A: electrons in different bins $\epsilon = N_2/N_1$

Case B: electrons in the same bin $\epsilon = 2N_2/(N_1 + N_2)$

Total efficiency is then:

$$\epsilon = \frac{N_2^A + 2N_2^B}{N_1^A + N_1^B + N_2^B} = \frac{N_2^A + 2N_2^B}{N_T}$$

Analysis Strategy

- Select events on e25i trigger
- Find good Z candidates using 2 electrons of opposite charge and reasonable mass cut
- Match reconstructed electrons to Level 2 trigger objects
- Check if matched trigger objects satisfy the trigger requirements
- Calculate efficiency as function of E_T, η, ϕ

Expect something like 97% at L1, 95% at L2, 94% at EF